THE WEATHER AND CIRCULATION OF NOVEMBER 1957[1]

A Stormy Month with a Deep Trough over Central North America

CHARLES M. WOFFINDEN

Extended Forcast Section, U. S. Weather Bureau, Washington, D. C.

1. THE NORTH AMERICAN TROUGH

The principal feature of the 700-mb. circulation for November 1957 (fig. 1) in North America was a deep full-latitude trough over the central portion of the continent. Associated departures from normal of 700-mb. height were negative over a broad area including most of the United States and central Canada. Over the United States the wave pattern of trough in the center of the country and ridge off each coast was almost the exact opposite of that described by Frazier [1] for October of this year. This pronounced break in regime, which has often characterized the change from October to November in the past [2], is well illustrated in figure 2 which shows sizeable height falls over almost the whole of North America, with rises limited mainly to offshore areas in the Atlantic and Pacific.

The changeover from October to November was a gradual one, and the first half of November (fig. 3A) exhibited characteristics of each regime. Although the Canadian trough became well established and extended into the United States, the pattern over the southern tier of States was out of phase and more characteristic of the October regime, with a trough off the southeastern coast and another in the Southwest. This latter feature moved inland during this period from its October position along the west coast and eventually joined the Canadian trough to produce the pronounced full-latitude system which dominated the pattern for the latter half-month (fig. 3B). The sharpening of this trough as its central portion deepened and the coastal ridges developed is evident from figure 3C, and it became sufficiently pronounced that it determined the circulation pattern for the month as a whole as well as the anomalies of weather.

2. OTHER FEATURES OF THE MEAN 700-MB. CIRCULATION

It is of interest to review the development of the North American trough in terms of other features of the planetary circulation for the month (fig. 1). In the Pacific the normally dominant Asiatic coastal trough was weak and confined to lower latitudes (except for the Low in the Sea of Okhotsk), and the central Pacific trough was the deeper and more pronounced system. This was particularly true of the latter half-month period when the trough in the central Pacific intensified and assumed a strong negative tilt (fig. 3B). This pattern evolved as the northern portion of the trough retrograded to the Bering Sea, while the southern part advanced to the Hawaiian Islands and deepened (fig. 3C). The reaction downstream was interesting, particularly at low latitudes. The west coast ridge and the trough in the Southwest moved eastward into alignment with their Canadian counterparts and became full-latitude features as described earlier. This phasing-in of the United States trough sharply altered the pattern downstream in the Atlantic as the low-latitude trough off the southeastern coast (fig. 3A) moved rapidly eastward into the central Atlantic, displacing the ridge formerly in that region. This ridge in turn progressed eastward and contributed to the blocking which became established over the British Isles during this period. A complete change of phase also resulted in this area since a pronounced trough previously occupied the region. Figure 3C highlights the extent of these adjustments.

3. BLOCKING

The 700-mb. zonal index for November averaged below normal for the fifth successive month. However it was higher (9.7 m. p. s.) than the October value of 7.3 m. p. s., and it climbed from 8.7 to 10.6 m. p. s. from the first to the latter half-month. This rather sizeable increase of nearly 2 m. p. s. brought the index to slightly above the normal value of 10.5 m. p. s. and was associated with a shift in the locale of blocking to lower latitudes in the Atlantic and to higher latitudes in the Pacific.

That blocking was a prominent feature of the Atlantic circulation is evident from the split westerlies (figs. 1 and 4) and the extensive area of positive height anomaly centered over Iceland. The center of positive departure from normal (340 ft.) migrated from the vicinity of Iceland during the first half of the month (fig. 3A) to the British Isles during the last half, where it became very persistent. The growth of this anomaly produced the largest single increase in 700-mb. height (620 ft.) between the two halves of the month (fig. 3C). The movement of the associated 5-day mean DN center, traced in figure 5, illustrates the tendency first to migrate toward, and then to remain over, the British Isles.

[1] See Charts I–XVII following p. 384 for analyzed climatological data for the month.

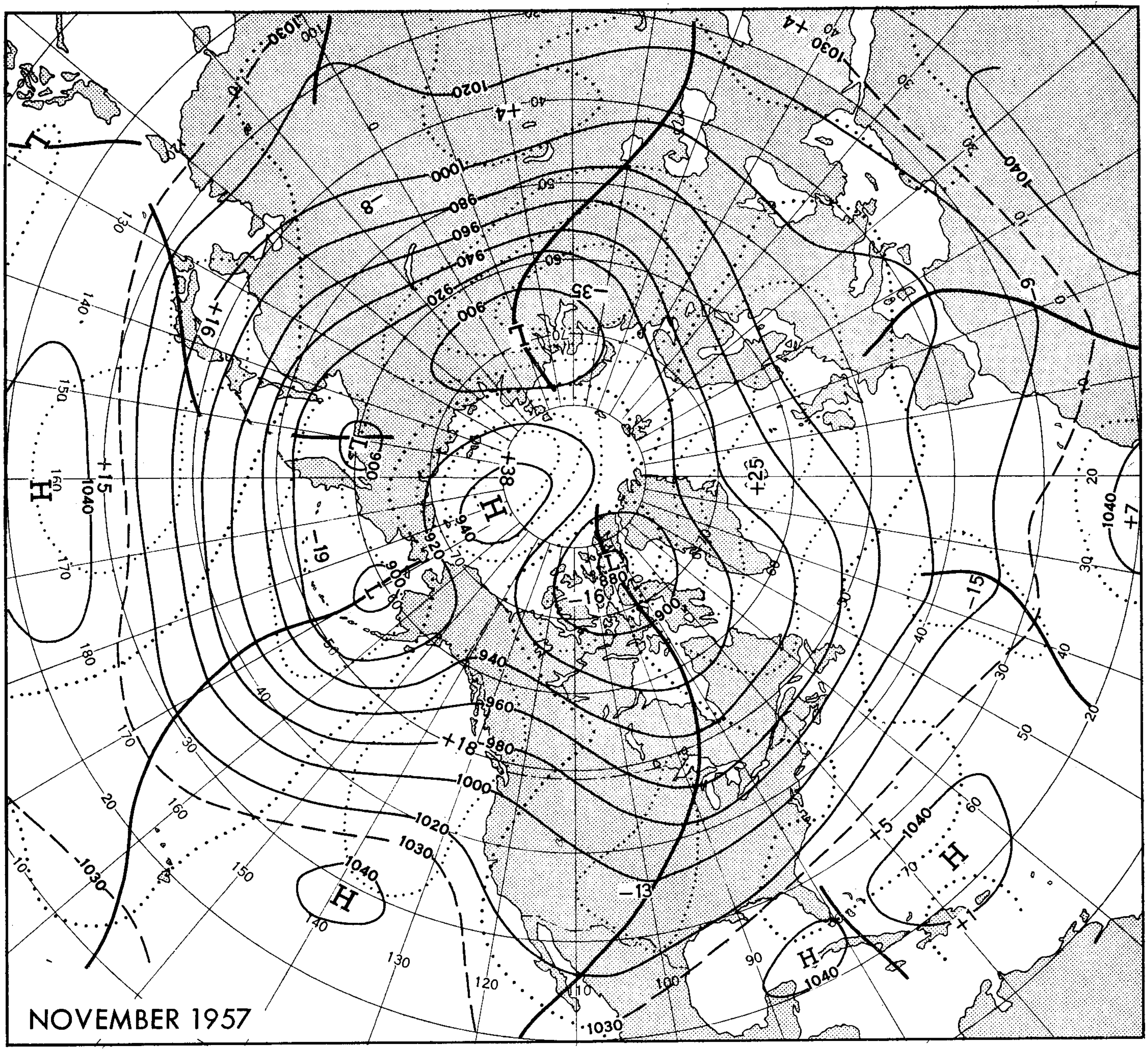

FIGURE 1.—Mean 700-mb. height contours (solid) and departures from normal (dotted) (both in tens of feet) for November 1957. A deep full-latitude trough (heavy vertical line) occupied central North America, with heights below normal over most of the United States and central Canada. Blocking was active over the northern Atlantic and over the polar basin north of the Bering Strait.

The Icelandic area was subject to intense cyclonic activity during October [1], and therefore the advent of blocking in that vicinity in November constituted a sharp reversal in circulation. This is attested by the large change center of +500 ft. observed on the difference chart between the two months (fig. 2).

A rather pronounced "wave of blocking" emanated from the North Atlantic region about mid-month and spread westward to influence North America. The center of positive anomaly split (indicated by the dashed line on fig. 5) during the 5-day mean period centered on the 14th, with a new center (+470 ft.) appearing in eastern Canada. This in turn intensified and retrograded bodily (solid line fig. 5) to northern Hudson Bay, only to separate into two centers once again as the area of positive anomaly subsequently spread westward. This time the new center (+250 ft.) appeared in the southeastern Gulf of Alaska on the mean chart for the 18th. This center remained stationary and intensified to +450 ft. on the mean chart centered on the 21st. However, the retrogression terminated at this point as the center of positive anomaly subsequently sank south-southeastward to a point off the California-Oregon coast and became affiliated with the subtropical ridge. Thus, this "surge" of

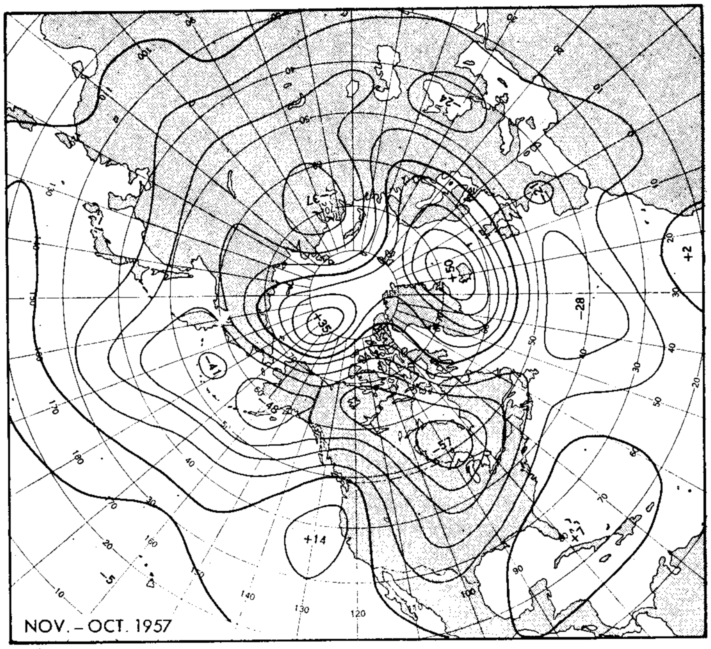

FIGURE 2.—Change in 700-mb. height from October to November 1957. The lines of equal height change are drawn at 50-ft. intervals with the zero line heavier and the centers labeled in tens of feet. The largest changes occured over central North America, illustrating the reversal from the October regime. Note the development of the cyclonic channel over the Aleutians, as blocking retreated to higher latitudes, and increased zonal flow developed to the south. Note also the large changes over Iceland as blocking supplanted the intense cyclonic activity of October.

blocking was accompanied by two periods of discontinuous retrogression of the type often described as typical [3, 4]. Its speed of progress upstream is somewhat difficult to assess. However, assuming a beginning with the first appearance of a positive center near Iceland on the mean chart centered on the 7th and an ending with the development of maximum intensity in the Gulf of Alaska (+450 ft. on the mean chart centered on the 21st), an average speed of approximately 60° longitude per week results, in good agreement with the findings of other studies on blocking [4, 5, 6].

As the center of blocking in the Atlantic shifted from Iceland to the lower latitude of Britian during the month it assumed more of the nature of a middle-latitude block with a stronger connection with the subtropical ridge (fig. 3B). In the Pacific, by contrast, blocking was mainly a high-latitude phenomenon and was located over Arctic waters north of Bering Strait (fig. 1). It developed greater intensity than its Atlantic counterpart since a closed polar High formed with associated departure from normal on the monthly mean chart (fig. 1) of +380 ft., compared to +250 ft. in the Atlantic.

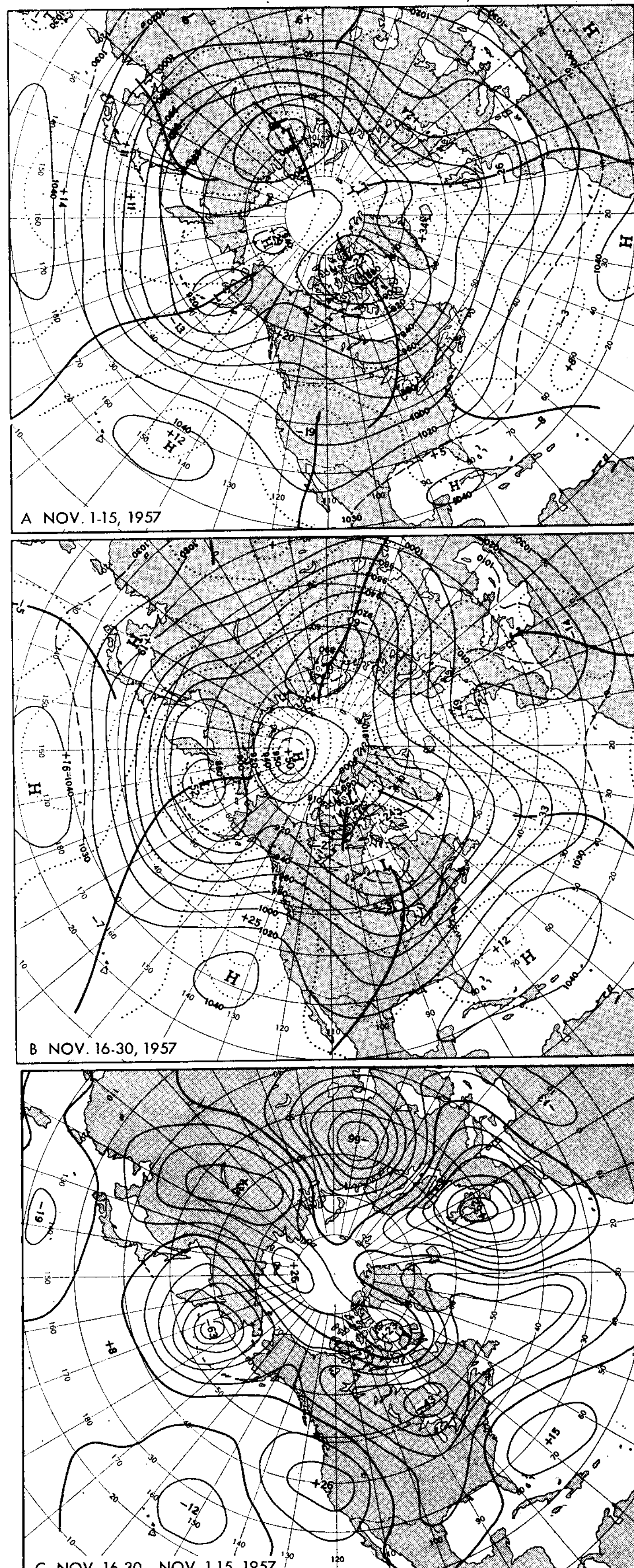

FIGURE 3.—Fifteen-day mean contours (solid) and height departures from normal (dotted) at 700 mb. (both in tens of feet) for (A) November 1–15, and (B) November 16–30, 1957, together with (C) the difference between the two. The North American trough intensified and extended to lower latitudes in accord with the amplification of pattern and increase in westerlies over the Pacific. Note the mid-latitude block over Britain and the large intra-month change which occurred there.

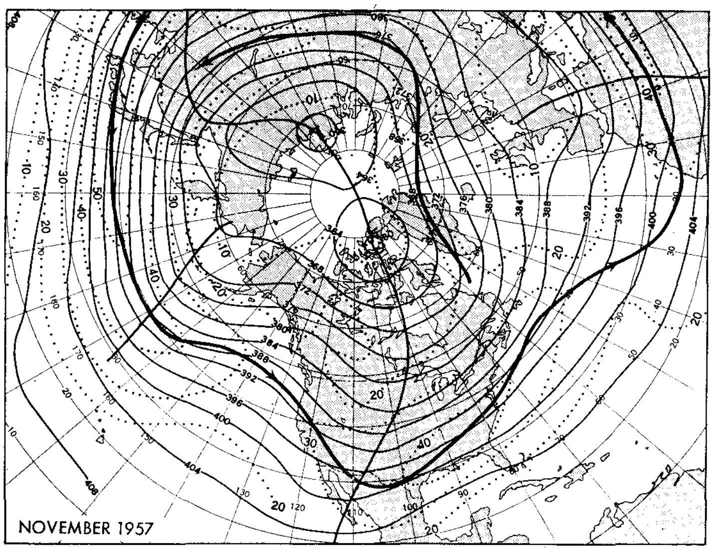

FIGURE 4.—Mean 200-mb. contours (solid, in hundreds of feet) and isotachs (dotted, in meters per second) for November 1957. Solid arrows indicate the position of the mean 200-mb. jet stream which was strong and single in the Pacific and across the southern border of the United States, but weaker and split across the Atlantic.

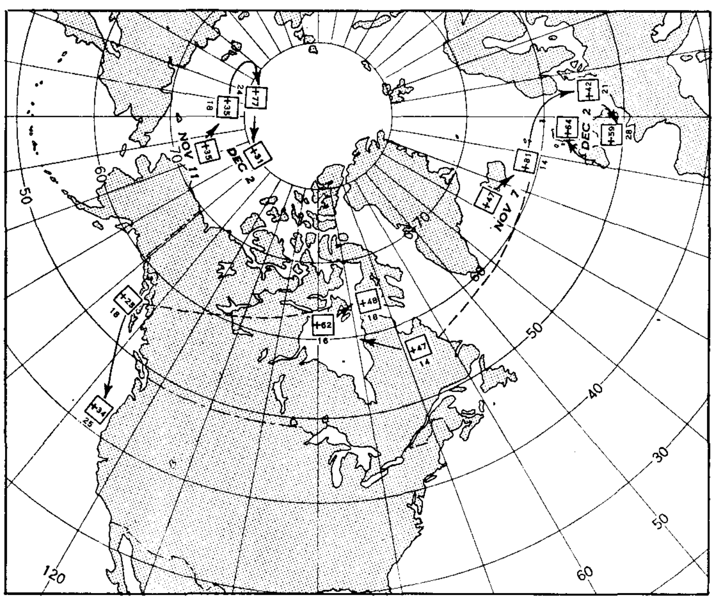

FIGURE 5.—Trajectories of two outstanding centers of positive 700-mb. height anomaly during November 1957. Weekly positions (except where indicated) of the center of each anomaly on a series of 5-day mean charts are located by the boxes. The intensity of the center (in tens of feet) is entered in the box and the middle date of the 5-day mean period beneath it. The solid line indicates translation of the whole center, and the dashed line discontinuous retrogression or split centers. Note that one blocking surge left the Atlantic on the 14th, became established over northeastern Canada, and served as the parent center for another retrograde wave which began to influence the Gulf of Alaska on the 18th.

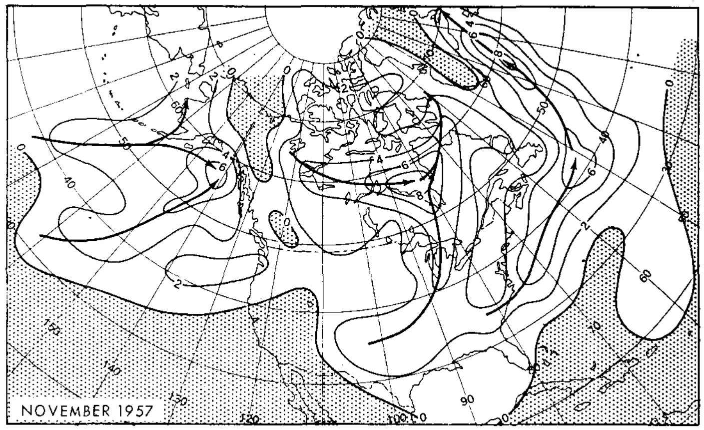

FIGURE 6.—Frequency of cyclone passages (within 5° squares at 45° N.) during November 1957. Note well-defined track (heavy arrow) from northern Texas to James Bay and the tendency for Atlantic storms to be deflected around the Atlantic block.

During October blocking was active mainly over Alaska and western Canada [1], and a vestige thereof appears to have remained during the first half of November in the form of the positive 200-ft. DN center over the Canadian Rockies and the difluent flow along the west coast of North America (fig. 3A). However, the tendency to shift to higher latitudes during the first half-month was clearly indicated by the appearance of a closed High over the polar basin with positive height anomaly of 290 ft. (fig. 3A). It was during the second half-month, however, that this anticyclone became most intense and persistent in that area and dominated the whole polar region. As this happened, the depression to its south in the Bering Sea deepened markedly, with heights diminishing during the half month by 630 ft. (fig. 3C) and during the full month by 410 ft. (fig. 2). It was this tendency for blocking to retreat to very high latitudes, and for cyclogenesis to occur over Alaska and the Bering Sea, which initiated the rise in index in the Pacific during the last half-month. This increase in index is well indicated by the marked change in flow components shown at middle latitudes on figure 2.

4. WEATHER AND CIRCULATION IN THE UNITED STATES

November was a stormy month for most of the country. The deep mean trough in the central United States at 700 mb. (fig. 1) and at 200 mb. (fig. 4) favored a temperature regime of cold in the West versus warm in the East. The baroclinic zone thus established gave rise to frequent intense storminess, and several major systems followed the favored course for the month from Texas northeastward through the Great Lakes and into James Bay. The individual tracks of these cyclones are shown in Chart X, and cyclone frequency per unit box together with principal tracks are summarized in figure 6. One or two centers moved along the southern border and joined the Atlantic storm track extending from South Carolina east-northeastward and thence north-northeastward toward Iceland. It is noteworthy that this track, like the one in central United States, closely resembled the climatologically preferred track for November [7].

The mean relative vorticity at 700 mb. for the month, charted in figure 7, further illustrates the intensity of the well-organized cyclonic channel in central United States and, in addition, indicates its tendency to extend across the mountains into New Mexico and Arizona. No fewer than five vigorous storms traversed this channel and brought cold waves, record snows, local flooding, and damaging high winds in thunderstorms and tornadoes.

One of these, of particular severity, was spawned in the Gulf of Mexico as the 700-mb. mean trough (fig. 3A) moved into the Southwest early in the month. It deepened rapidly as it moved toward the Lakes and was responsible for flood rains of 6 to 8 in. over northeastern Texas, heavy snows in the Ohio Valley and Great Lakes region, high winds of 40 to 50 m. p. h. from the northern and central Plains to the Appalachians, severe thunderstorm and tornado activity in the South from Texas eastward to North Carolina, and a cold wave in its wake. The Texas floods reached record proportions at Hagansport on the Sulphur River, with a flood crest of 45.6 ft. on November 6. This exceeded the previous record of 45.3 ft. which was recorded, oddly enough, 11 years previously to the day.

Severe storminess continued during the latter half of the month and produced another rash of heavy snows extending from the Rockies to the Great Lakes, with excessive rains and flooding again occurring in the southern States from Texas eastward. Tornadoes were reported in Alabama, Mississippi, Texas, Kentucky, and Tennessee. A particularly damaging one spread destruction in the suburbs of Fort Worth, Tex. on November 17.

Because of this cyclonic activity, precipitation was abundant over most of the country (Chart III–B). The only sizeable areas receiving less than 75 percent of monthly normal were the Northern Rocky Mountain States and the extreme Southwest. Precipitation totals exceeded the normal amount over most of the remainder of the country, were greater than twice the normal over a broad tier of southern States from New Mexico and northern Arizona to the Atlantic coast, and even exceeded 400 percent of normal along the Texas-Oklahoma border and in southeastern Colorado. Comparison of rainfall distribution (Chart III–B) with the 200-mb. flow (fig. 4) reveals that the axis of precipitation corresponded closely with the speed maximum of the mean 200-mb. jet stream over the Southeast. It is also noteworthy that the area under this jet maximum encompassed most of the tornado activity which occurred during the month, in good agreement with the findings of Dunn [8] for May 1957.

Numerous precipitation records were broken. It was the wettest November of record at Cairo, Ill., 13.05 in.; Louisville, Ky., 9.12 in.; Winston-Salem, N. C., 7.15 in.; and Brownsville, Tex., 6.26 in. In addition, new records

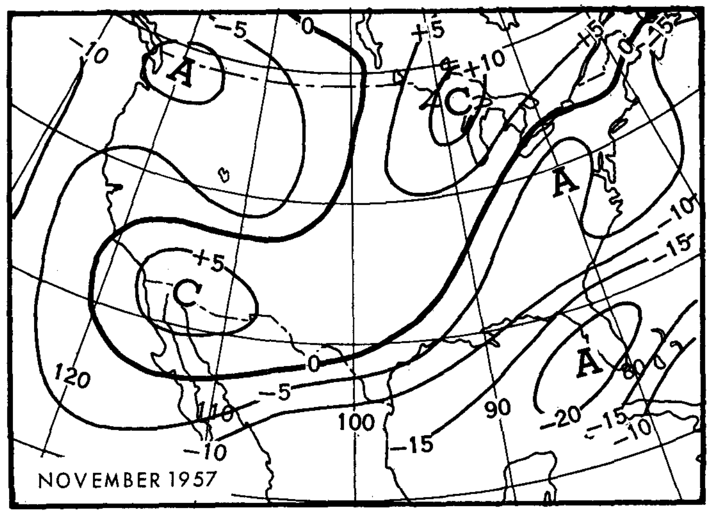

Figure 7.—Vertical component of mean geostrophic relative vorticity at 700 mb. for November 1957 (in units of 10^{-6} sec. $^{-1}$). Cyclonic and anticyclonic vorticity are considered positive and negative, respectively, and labeled C and A at centers. Note the marked channel of cyclonic vorticity extending from southern Arizona to the Great Lakes.

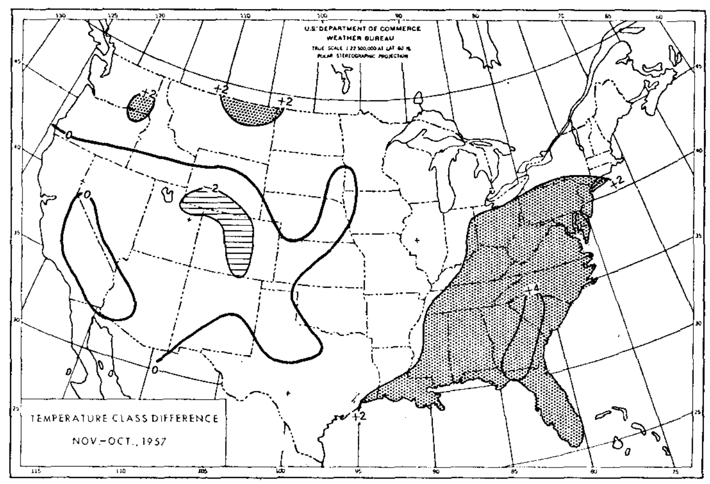

Figure 8.—Number of classes the anomaly of temperature changed from October to November 1957, with warming considered positive. Temperatures increased over the eastern half of the country, with the largest changes in the Southeast.

of snowfall were established at Lander, Wyo. and Raton, N. Mex. with 32.5 and 14.5 in. respectively. Also, records of 24-hour snowfall were closely approached or exceeded at several locations in the Central Plains. A 10.2-in. deposit at Concordia, Kans. on the 17–18th, for example, established a new 24-hour record for that station.

Not only were monthly totals excessive, but several stations have accumulated record or near record amounts for the first 11 months of the year and have excellent chances of setting new annual rainfall records. Among these, Dallas, Tex. has a total of 53.00 in. so far this year, which already exceeds any annual total observed in that station's history. At San Antonio an accumulation to date of 47.91 in. betters all previous yearly totals except for 50.30 in. in 1919. These figures are rendered all the more impressive when it is recalled that drought conditions prevailed over Texas for the years from 1952 to 1956.

In sharp contrast, and despite above normal precipitation during November, Hartford, Conn., and Providence, R. I., have experienced their driest January-through-November periods of record. At Trenton, N. J., November was the 7th consecutive month with subnormal precipitation, and a sizable deficit of about 13 inches has been recorded so far this year.

Temperature variations during the month, while not as spectacular as those of precipitation, were nevertheless of considerable interest. Monthly averages (Chart I–B) were cool in the West, departing from the normal as much as $-4°$ to $-6°$ F. over the Great Basin and West Texas. Temperatures were somewhat warmer in the East and in the Northern Plains, but, with the exception of the extreme Northwest and Northern Plains, positive departures were not large, averaging around 2° F. This was a consequence of the flatness of the ridge in advance of the United States trough which allowed occasional outbreaks of cold air to penetrate into the East. This was particularly the case during the first half-month when the low-latitude trough still prevailed off the southeastern coast as previously described. Cooler weather during this period tended to cancel out the warmer conditions which generally prevailed thereafter [9].

The trend to milder temperatures in the East also typified the change from October. The difference in temperature classes between the two months is depicted in figure 8, which illustrates the tendency for temperatures to reverse in the East and particularly in the Southeast, where warming of 3 and even 4 classes was observed. Smaller changes were the rule in the Southwest, though these were generally of opposite sign.

This temperature pattern, and its change from October, together with the widespread storminess and precipitation, all reflect the pre-eminence of the trough in the central United States during the month, at all levels from sea level up to 100 mb. (Charts XI to XVII).

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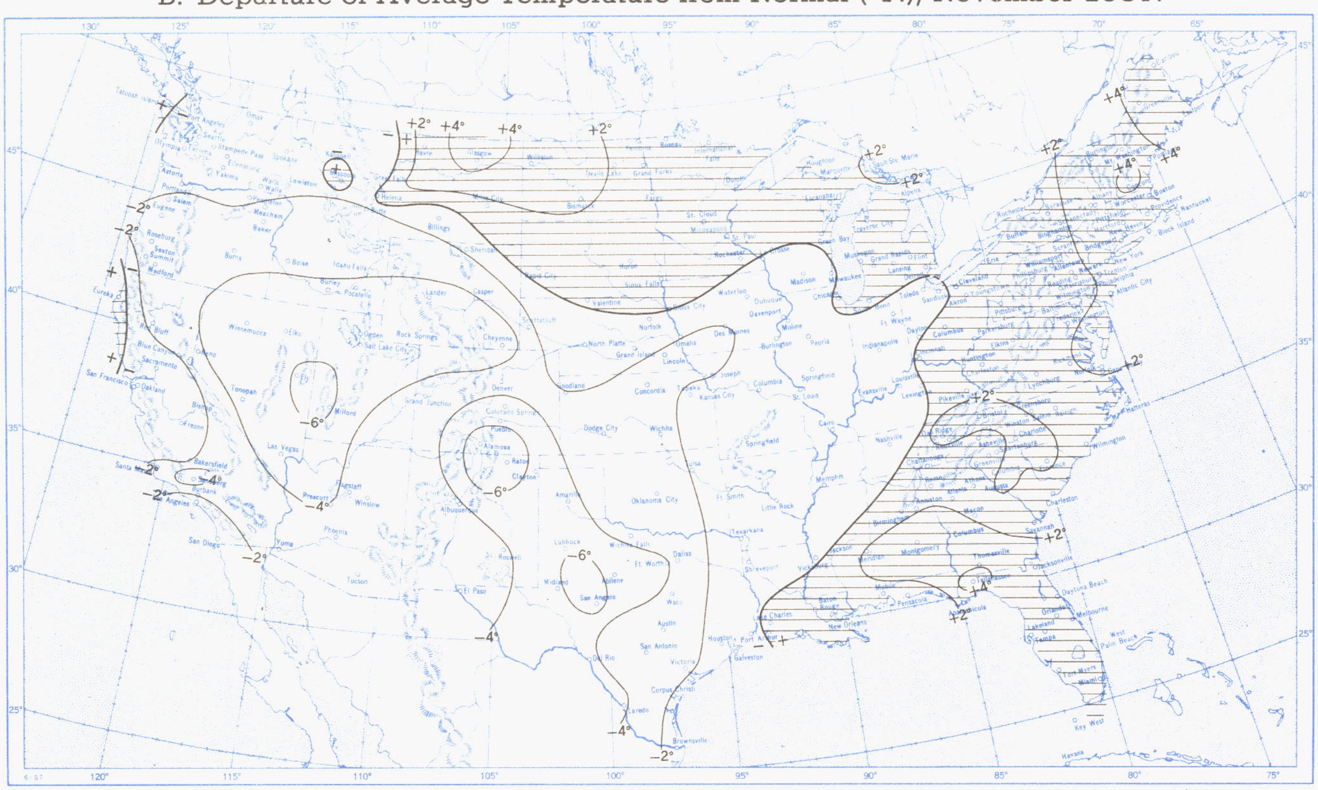
9. U. S. Weather Bureau, *Weekly Weather and Crop Bulletin, National Summary*, vol. XLIV, Nos. 45–47, Nov. 11, 18, and 25, 1957.

Chart I. A. Average Temperature (°F.) at Surface, November 1957.

B. Departure of Average Temperature from Normal (°F.), November 1957.



A. Based on reports from over 900 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
B. Departures from normal are based on the 30-yr. normals (1921-50) for Weather Bureau stations and on means of 25 years or more (mostly 1931-55) for cooperative stations.

Chart II. Total Precipitation (Inches), November 1957.

Based on daily precipitation records at about 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), November 1957.

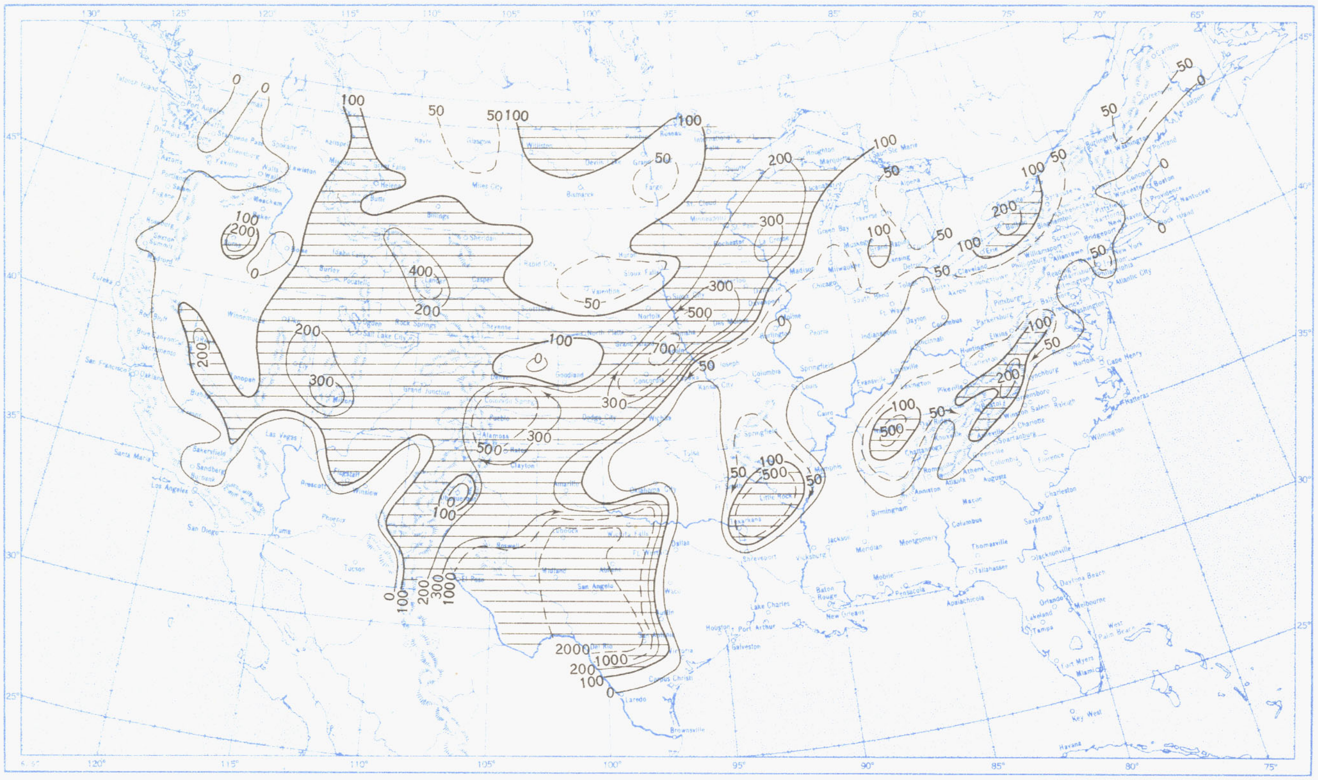
B. Percentage of Normal Precipitation, November 1957.

Normal monthly precipitation amounts are computed from the records for 1921-50 for Weather Bureau stations and from records of 25 years or more (mostly 1931-55) for cooperative stations.

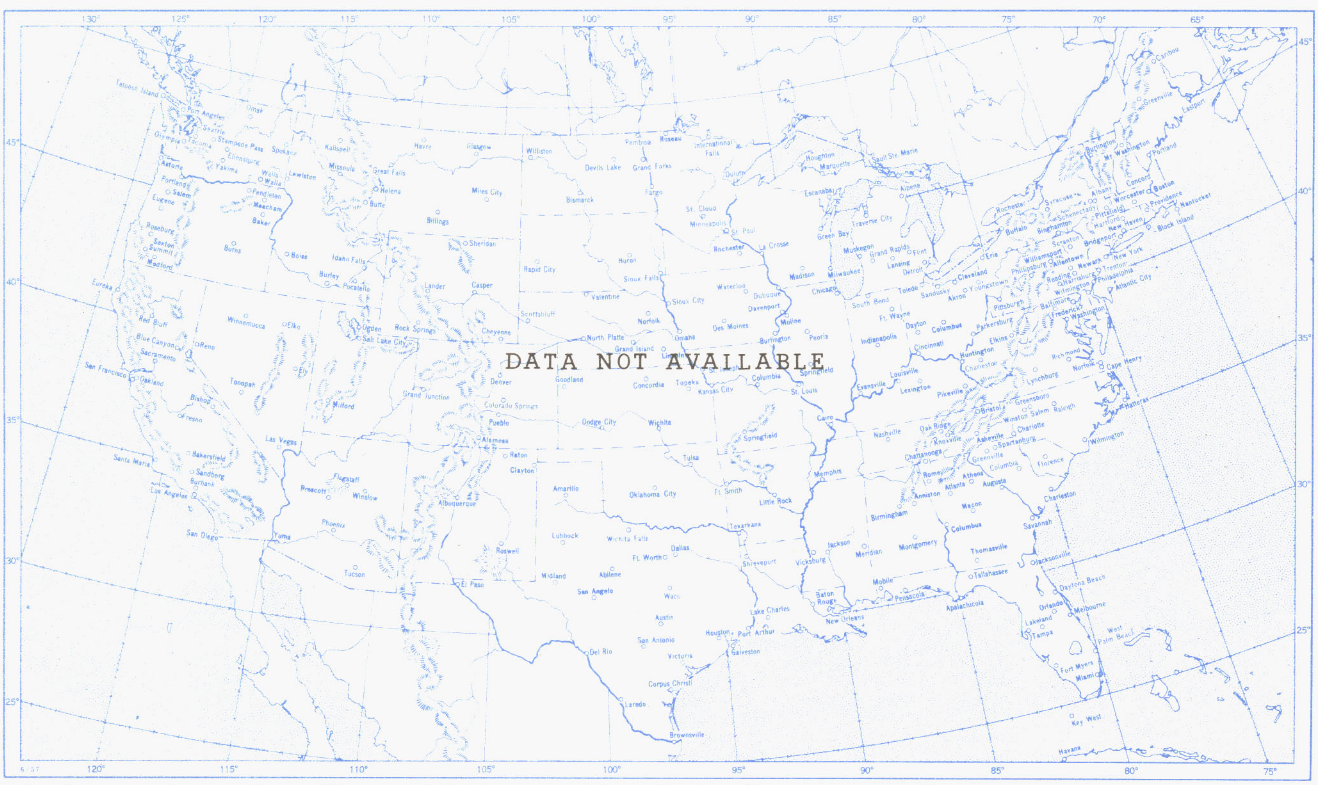
Chart IV. Total Snowfall (Inches), November 1957.

This is the total of unmelted snowfall recorded during the month at Weather Bureau and cooperative stations. This chart and Chart V are published only for the months of November through April although of course there is some snow at higher elevations, particularly in the far West, earlier and later in the year.

Chart V. A. Percentage of Normal Snowfall, November 1957.

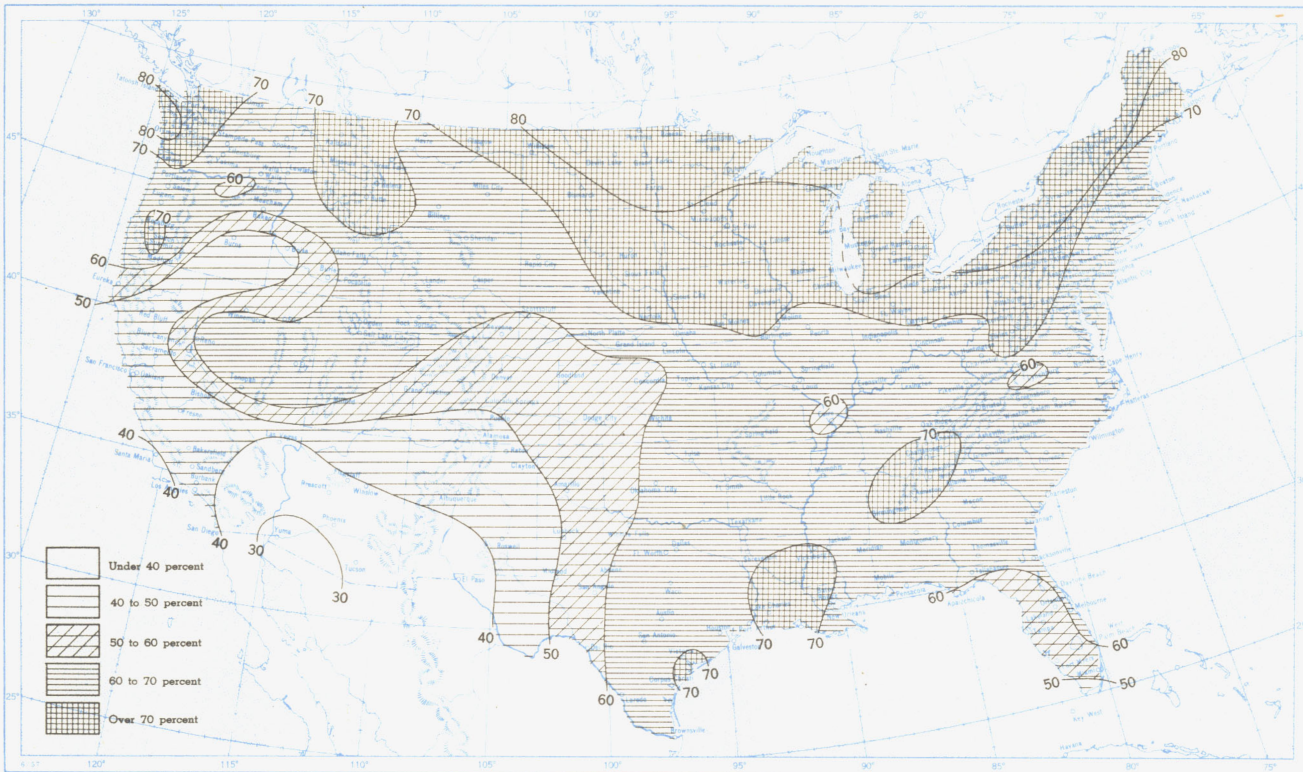


B. Depth of Snow on Ground (Inches), 7:00 a. m. E. S. T.

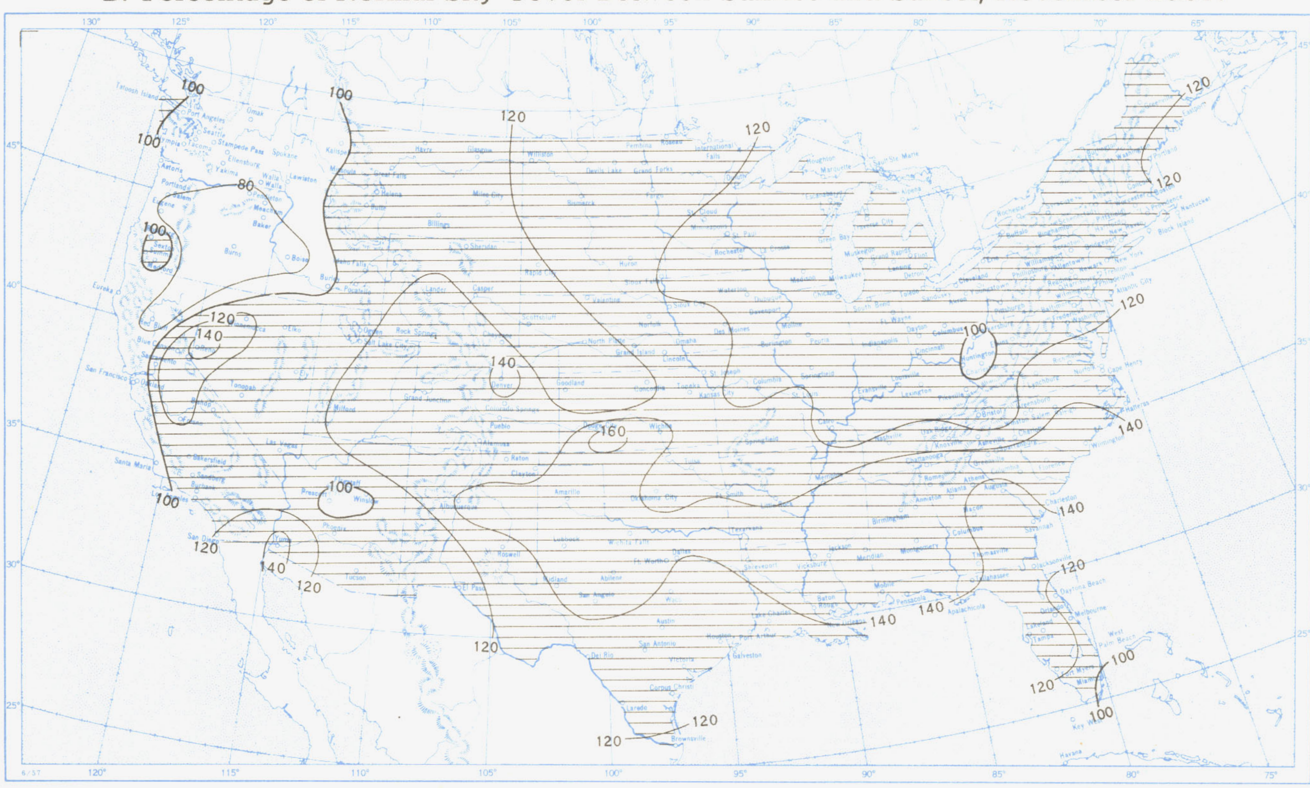


A. Amount of normal monthly snowfall is computed for Weather Bureau stations having at least 10 years of record.
B. Shows depth currently on ground at 7:00 a. m. E.S.T., of the Monday nearest the end of the month. It is based on reports from Weather Bureau and cooperative stations. Dashed line shows greatest southern extent of snowcover during month.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, November 1957.

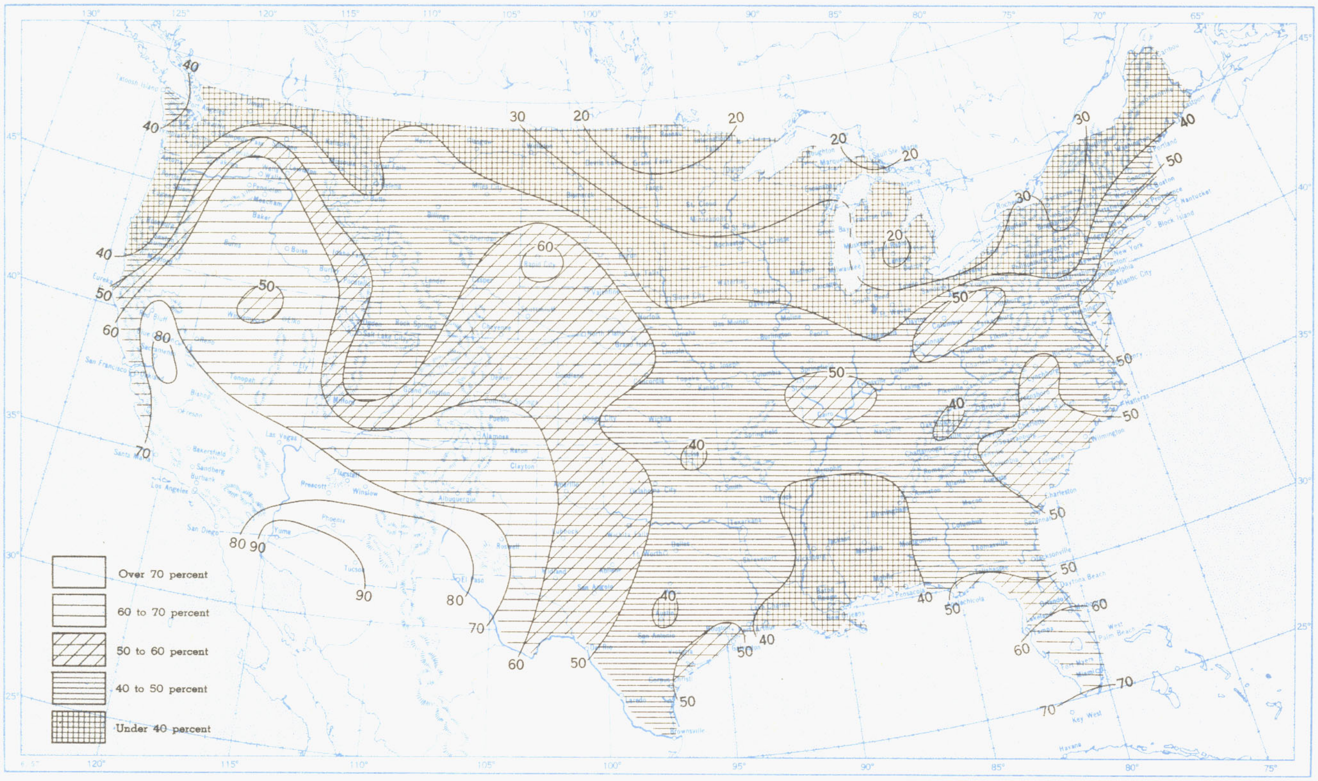


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, November 1957.

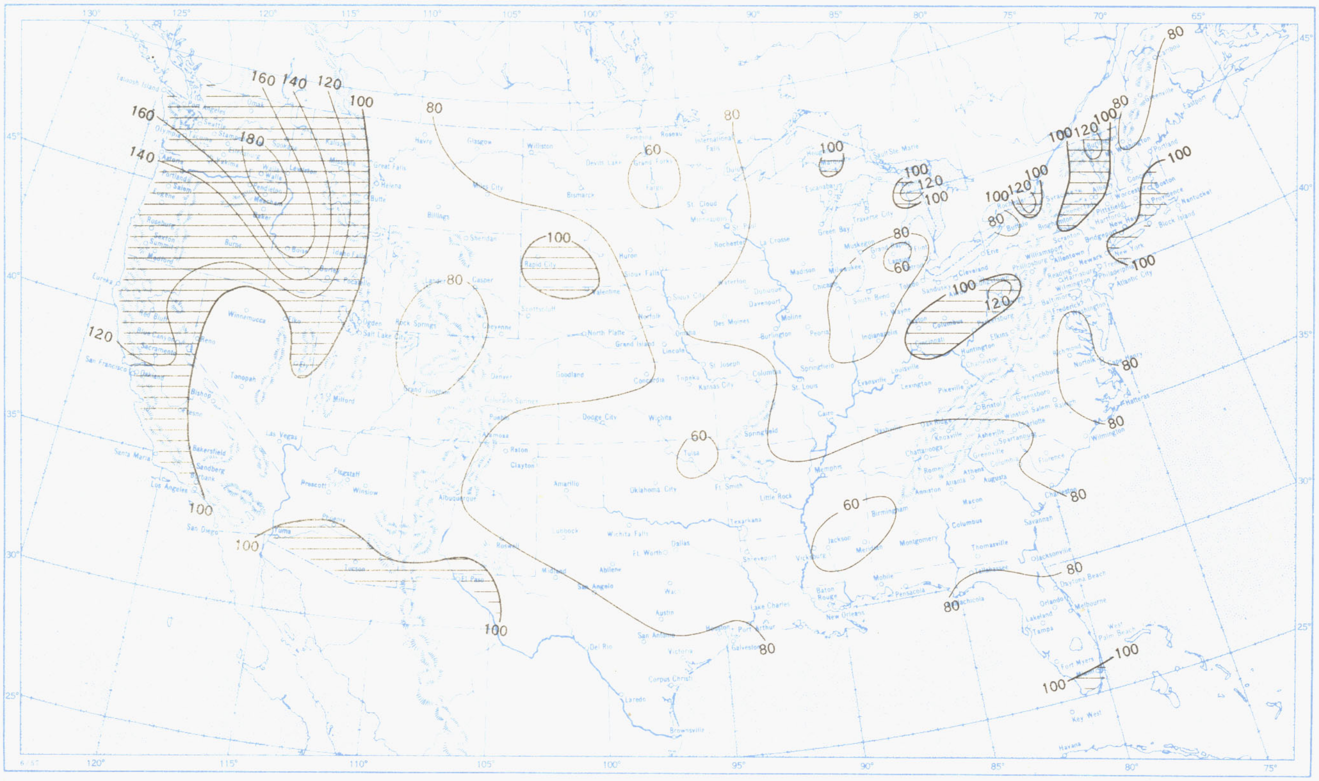


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, November 1957.



B. Percentage of Normal Sunshine, November 1957.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, November 1957. Inset: Percentage of Mean Daily Solar Radiation, November 1957. (Mean based on period 1951-55.)

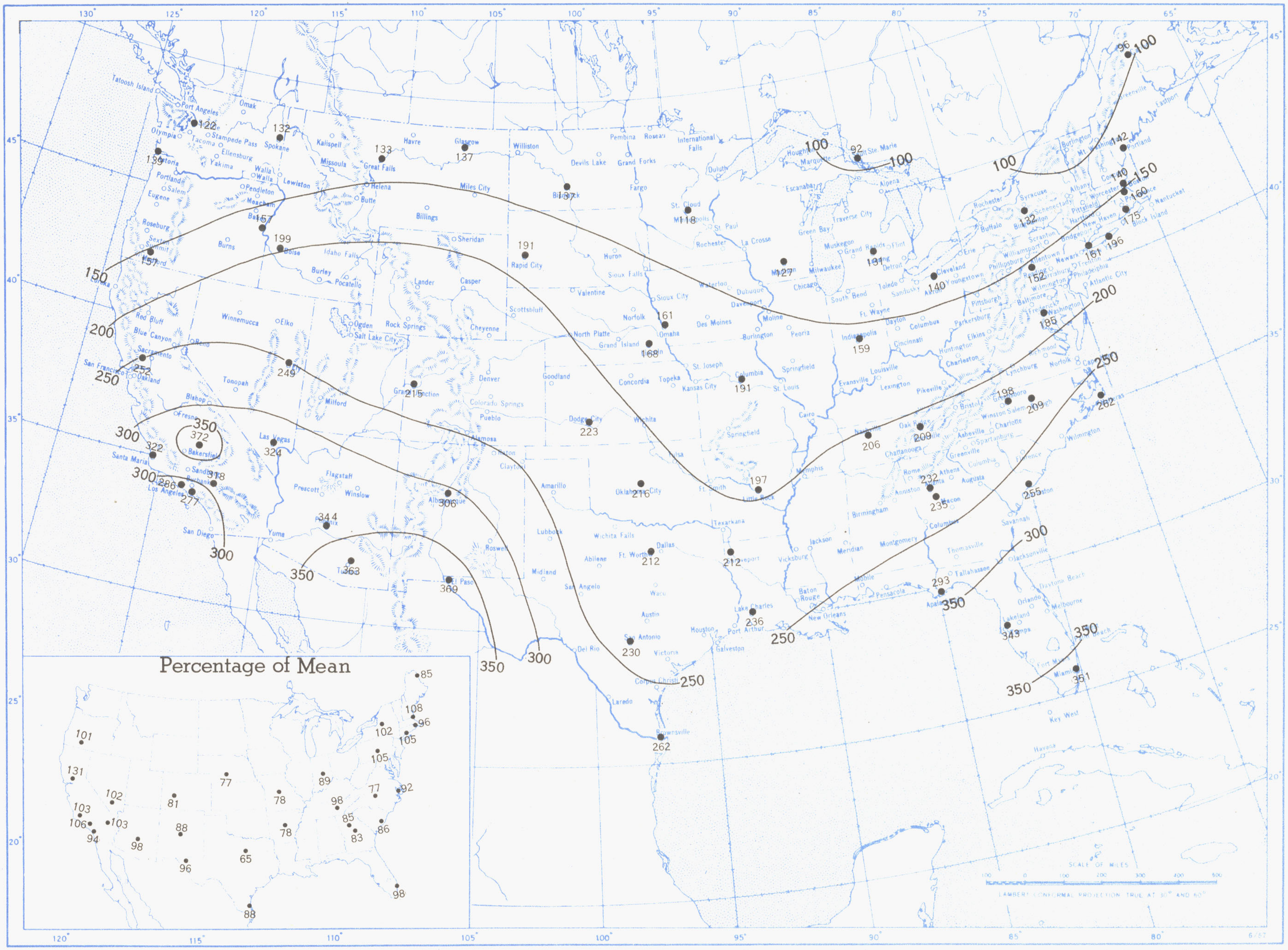
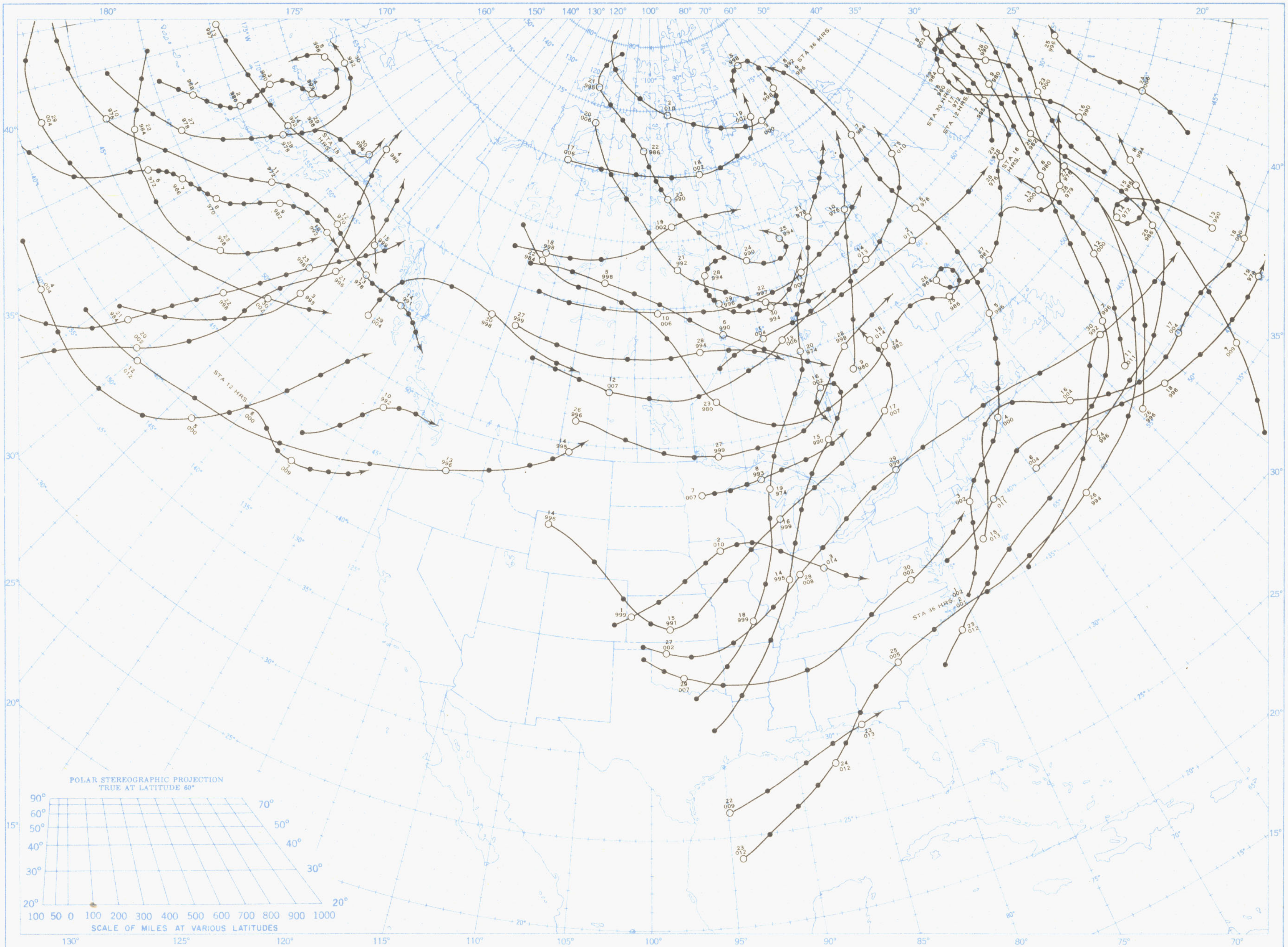


Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm. $^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. The inset shows the percentage of the mean based on the period 1951-55.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, November 1957.

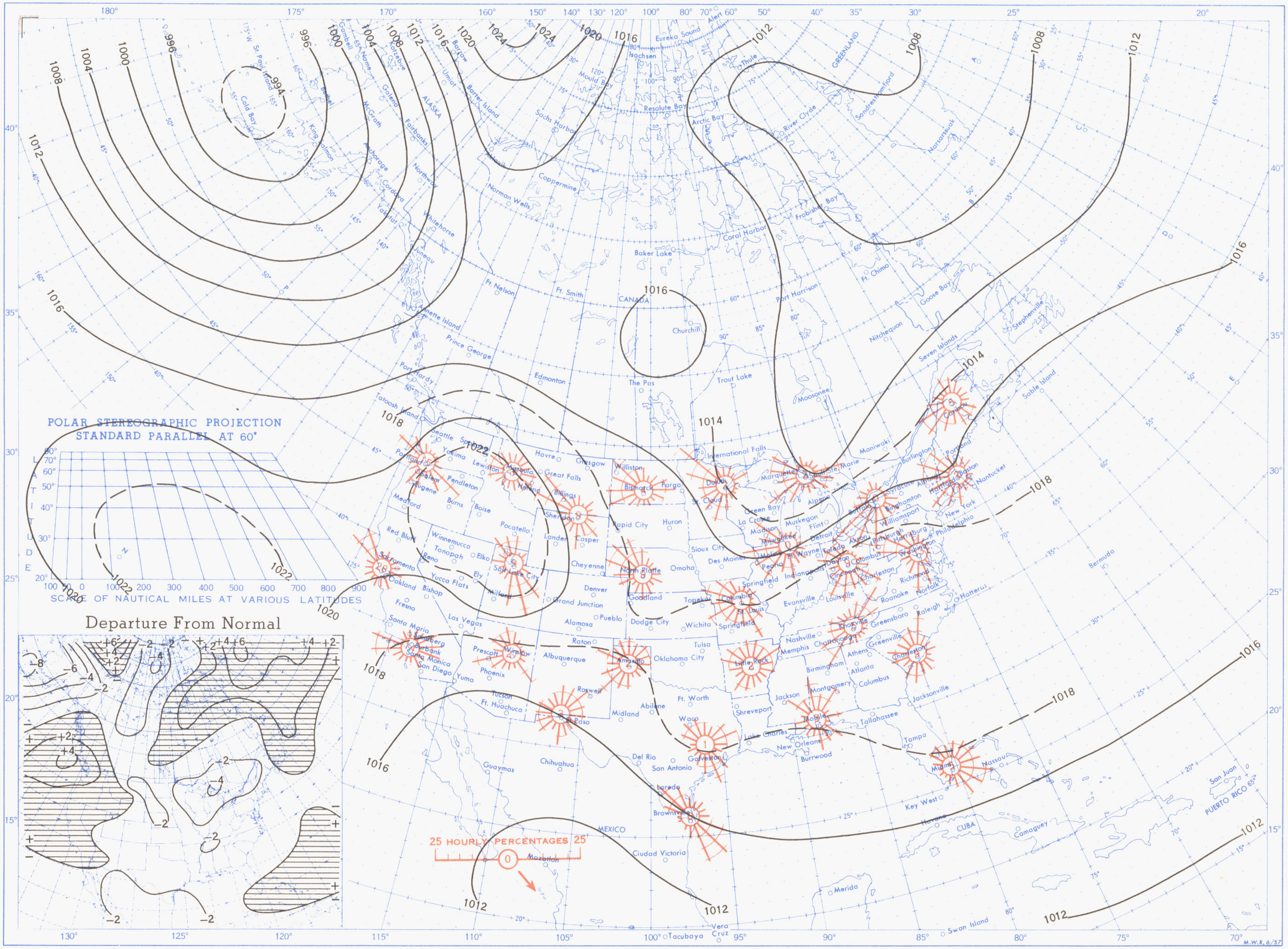
Circle indicates position of center at 7:00 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, November 1957.



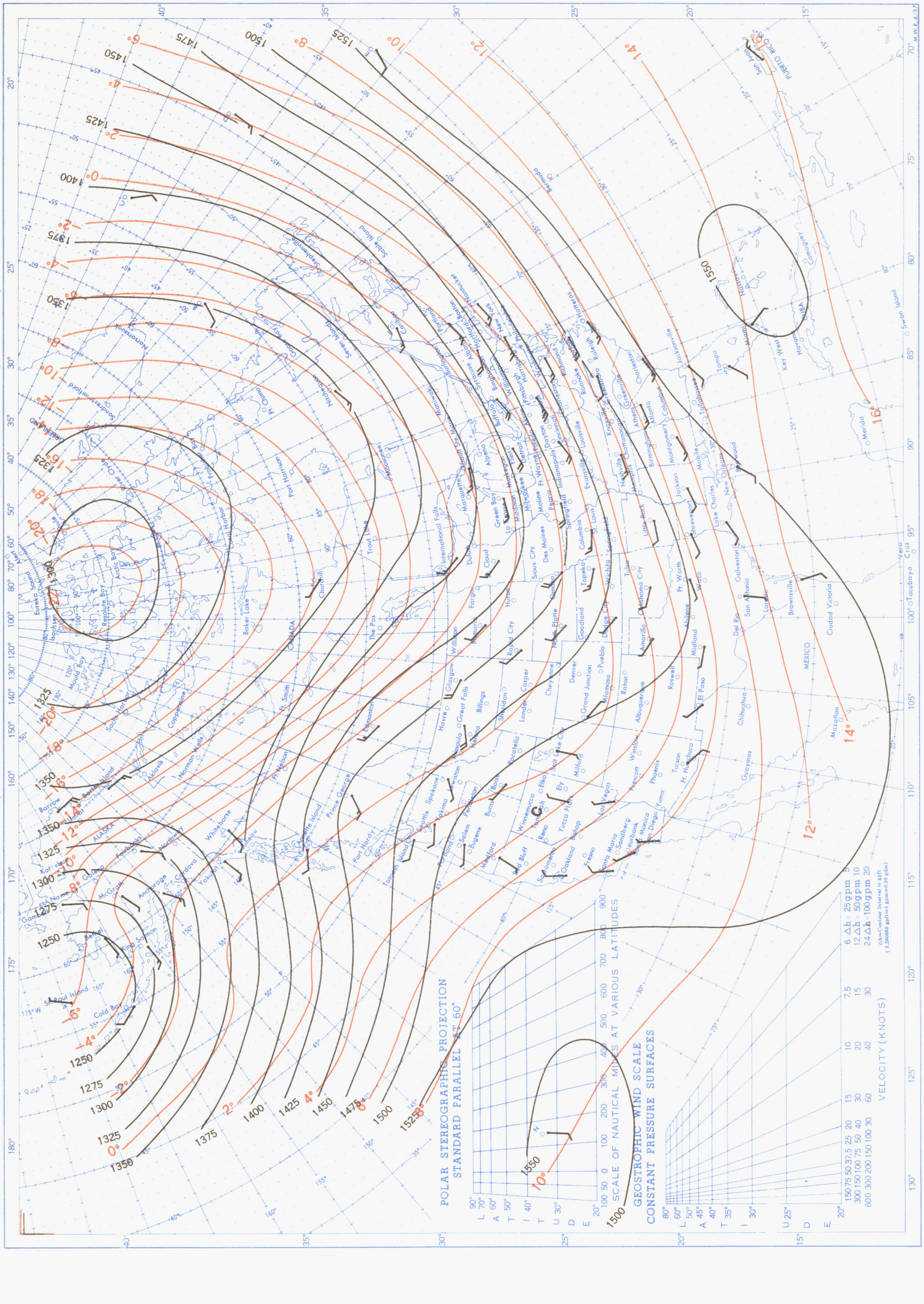
Circle indicates position of center at 7:00 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, November 1957. Inset: Departure of Average Pressure (mb.) from Normal, November 1957.



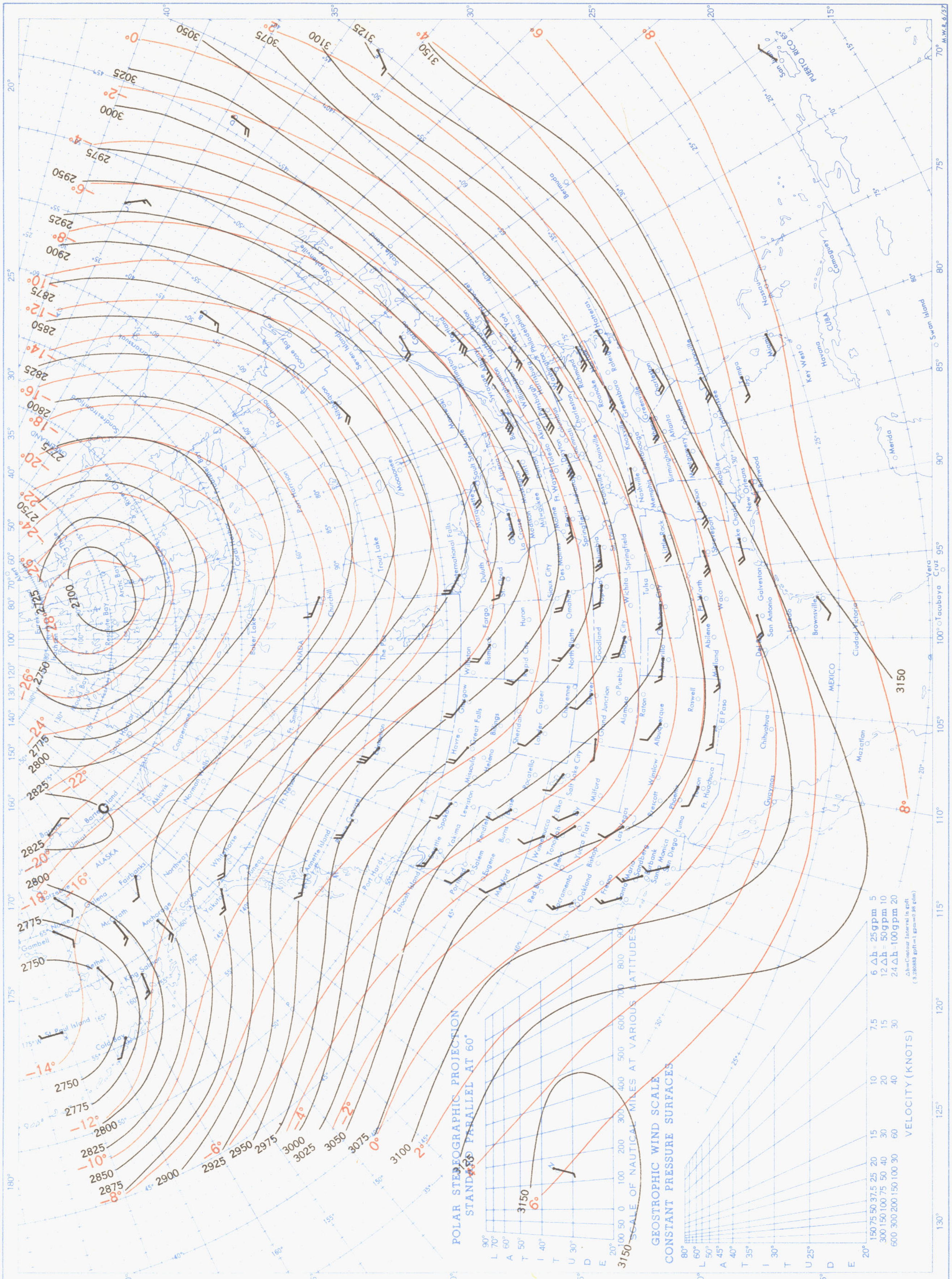
Average sea level pressures are obtained from the averages of the 7:00 a. m. and 7:00 p. m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. 850-mb. Surface, 1200 GMT, November 1957. Average Height and Temperature, and Resultant Winds.



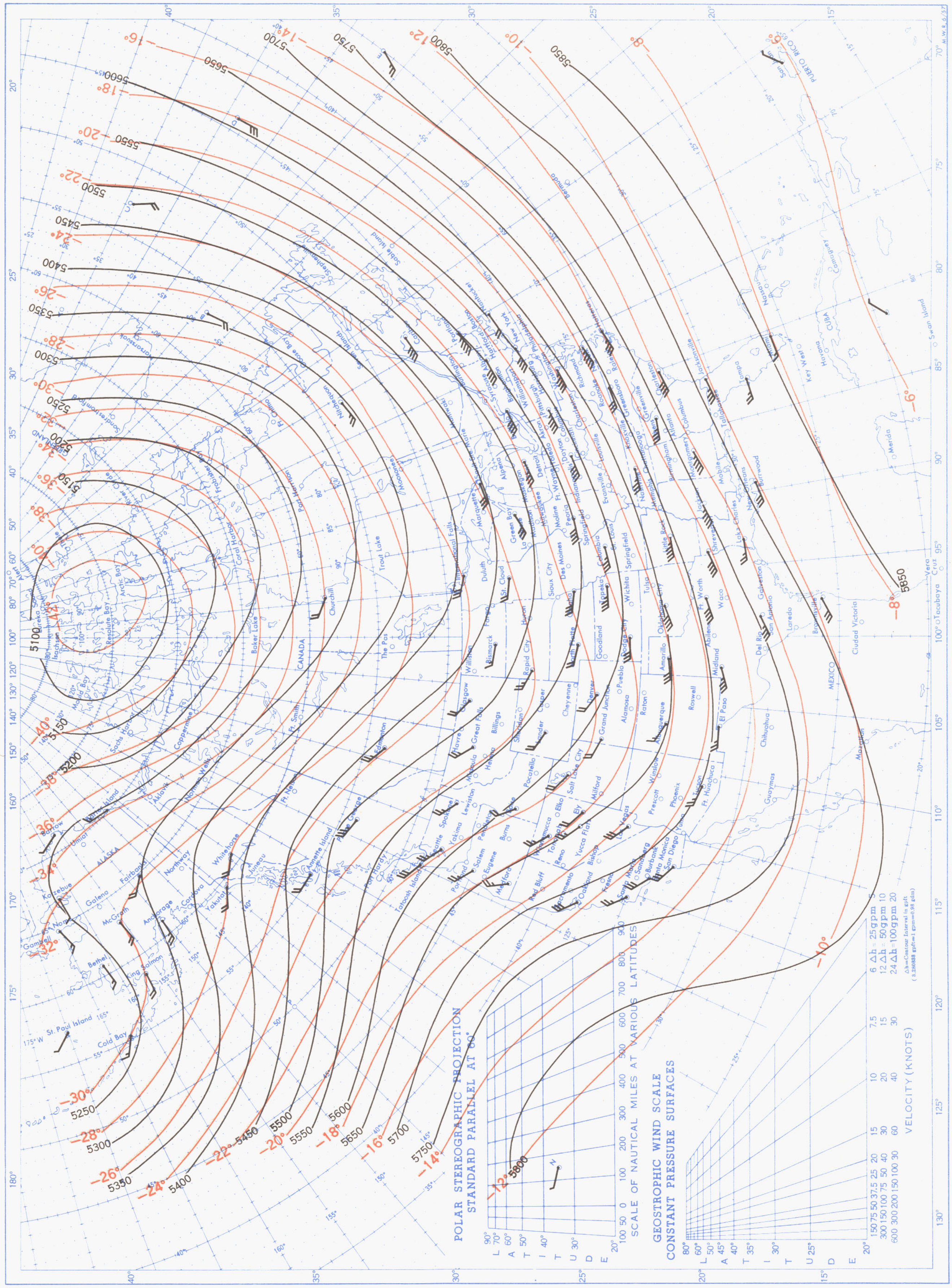
Height in geopotential meters (1 g.p.m. = 0.98 dynamic meters). Temperature in °C. Wind speed in knots; flag represents 50 knots, full feather 10 knots, and half feather 5 knots. All wind data are based on rawin observations.

Chart XIII. 700-mb. Surface, 1200 GMT, November 1957. Average Height and Temperature, and Resultant Winds.



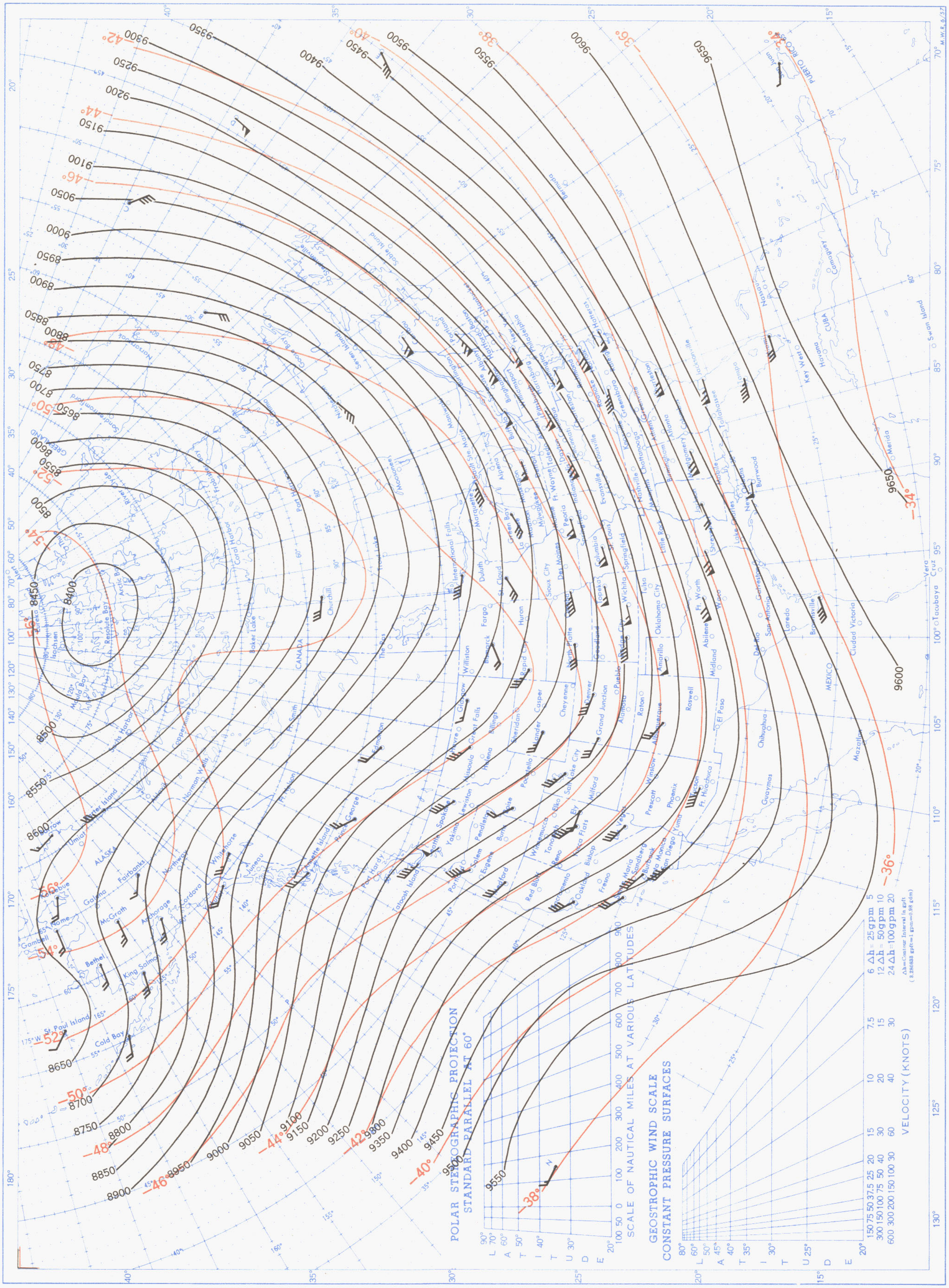
See Chart XII for explanation of map.

Chart XIV. 500-mb. Surface, 1200 GMT, November 1957. Average Height and Temperature, and Resultant Winds.



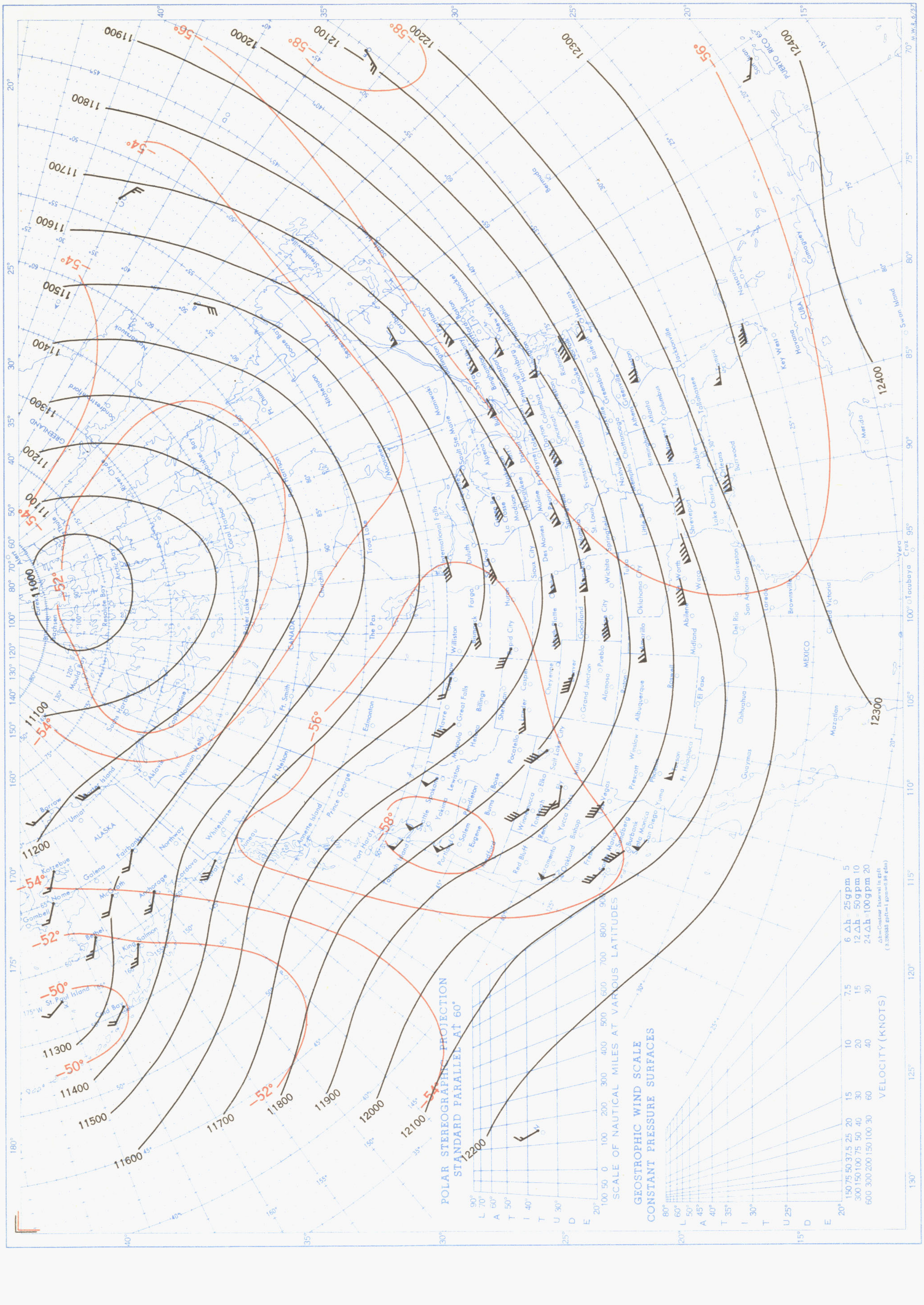
See Chart XII for explanation of map.

Chart XV. 300-mb. Surface, 1200 GMT, November 1957. Average Height and Temperature, and Resultant Winds.



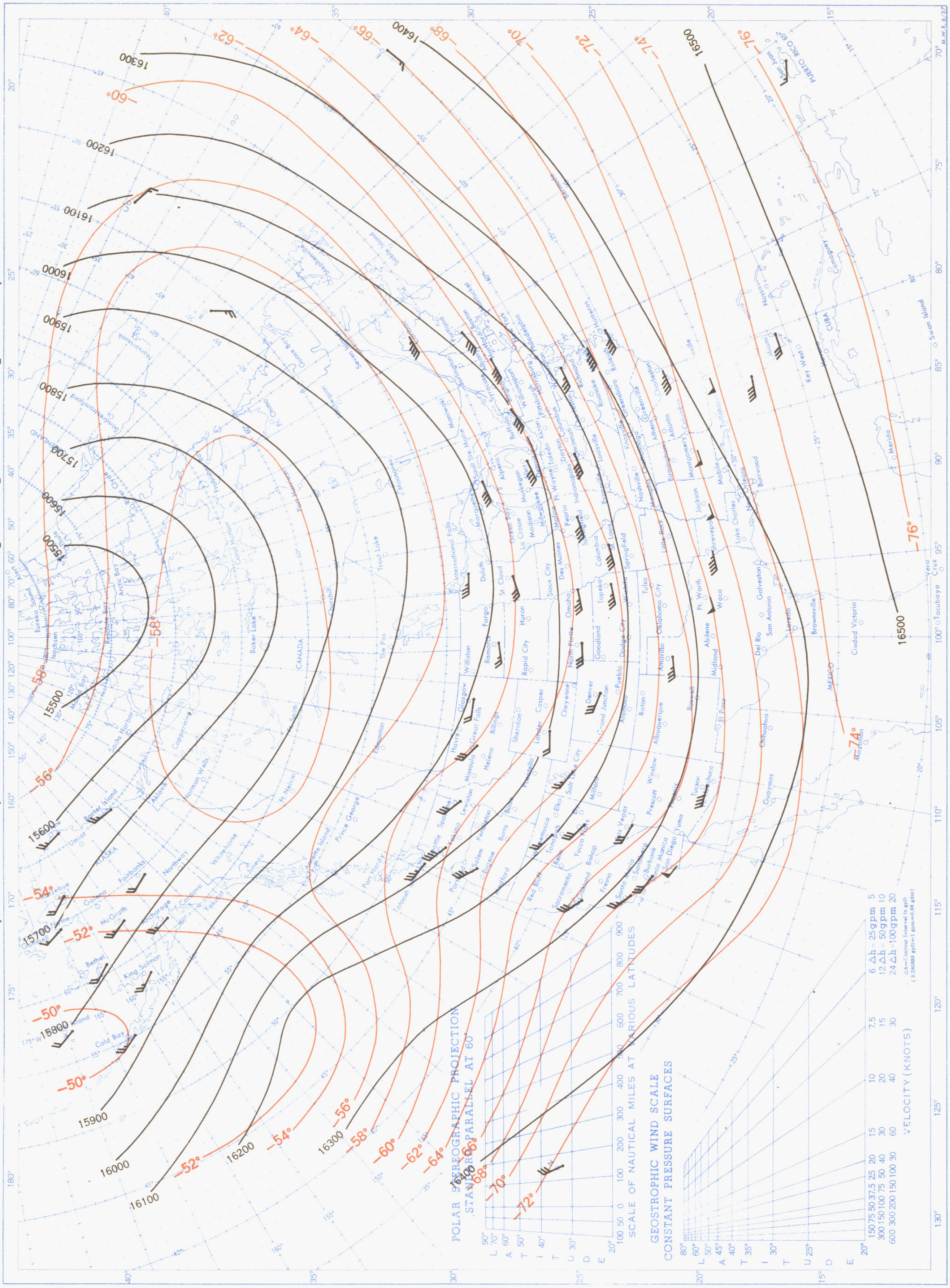
See Chart XII for explanation of map.

Chart XVI. 200-mb. Surface, 1200 GMT, November 1957. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map.

Chart XVII. 100-mb. Surface, 1200 GMT, November 1957. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map.